



### WHAT WE'RE DOING:

The Arduino's pins are great for directly controlling small electric items like LEDs. However, when dealing with larger items (like a toy motor or washing machine), an external transistor is required. A transistor is incredibly useful. It switches a lot of current using a much smaller current. A transistor has 3 pins. For a negative type (NPN) transistor, you connect your load to collector and the emitter to ground. Then when a small current flows from base to the emitter, a current will flow through the transistor and your motor will spin (this happens when we set our Arduino pin HIGH). There are literally thousands of different types of transistors, allowing every situation to be perfectly matched. We have chosen a P2N2222AG a rather common general purpose transistor. The important factors in our case are that its maximum voltage (40v) and its maximum current (600 milliamp) are both high enough for our toy motor (full details can be found on its datasheet <http://ardx.org/2222>).

(The 1N4001 diode is acting as a flyback diode for details on why its there visit: <http://ardx.org/4001>)

### THE CIRCUIT:

#### Parts:



**CIRC-03  
Breadboard Sheet  
x1**



**2 Pin Header  
x4**



**Transistor  
P2N2222AG (TO92)  
x1**

**Wire**



**Toy Motor  
x1**

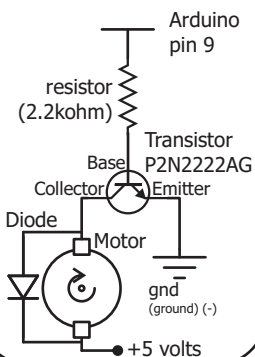


**Diode  
(1N4001)  
x1**



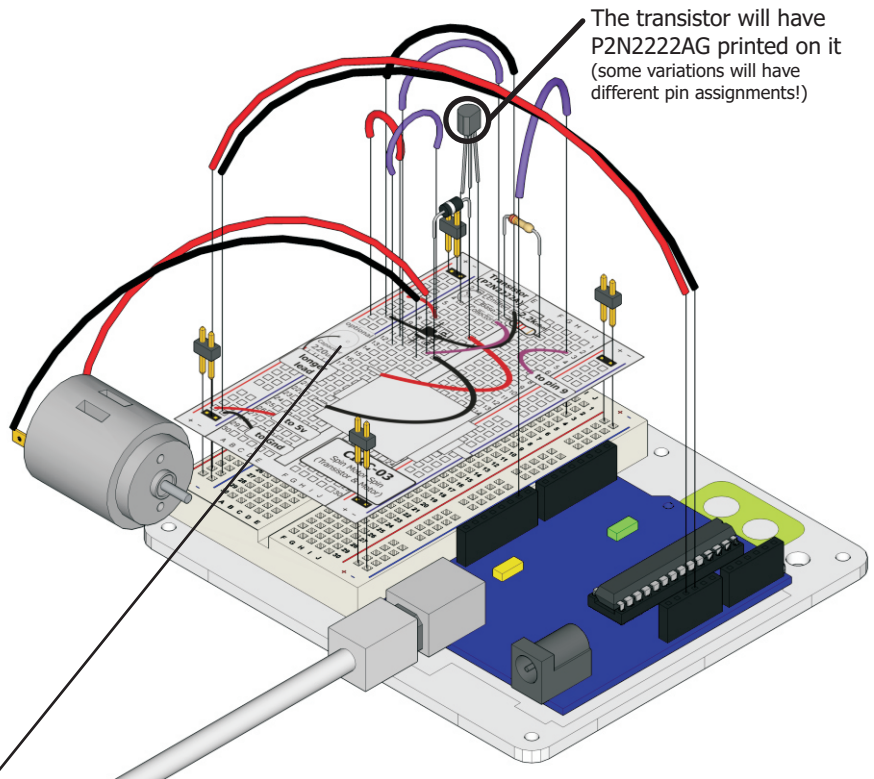
**2.2k Ohm Resistor  
Red-Red-Red  
x1**

#### Schematic



#### The Internet

**.:download.:  
breadboard layout sheet  
<http://ardx.org/BBL503>  
.:view.:  
assembly video  
<http://ardx.org/VIDE03>**



.:NOTE: if your arduino is resetting you need to install the optional capacitor.:.

## CODE (no need to type everything in just click)

# CIRC-03

### Download the Code from ( <http://ardx.org/CODE03> )

(then simply copy the text and paste it into an empty Arduino Sketch)

```
int motorPin = 9; //pin the motor is connected to

void setup() //runs once
{
  pinMode(motorPin, OUTPUT);
}

void loop()      // run over and over again
{
  motorOnThenOff();
  //motorOnThenOffwithSpeed();
  //motorAcceleration();
}

/*
 * motorOnThenOff() - turns motor on then off
 * (notice this code is identical to the code we
 * used for
 * the blinking LED)
 */
void motorOnThenOff(){
  int onTime = 2500; //on time
  int offTime = 1000; //off time
  digitalWrite(motorPin, HIGH);
  // turns the motor On
  delay(onTime); // waits for onTime milliseconds
  digitalWrite(motorPin, LOW);
  // turns the motor off
  delay(offTime); // waits for offTime milliseconds
}

void motorOnThenOffwithSpeed(){
  int onSpeed = 200; // a number between
  //0 (stopped) and 255 (full speed)
  int onTime = 2500;
  int offSpeed = 50; // a number between
  //0 (stopped) and 255 (full speed)
  int offTime = 1000;
  analogwrite(motorPin, onSpeed);
  // turns the motor On
  delay(onTime); // waits for onTime milliseconds
  analogwrite(motorPin, offSpeed);
  // turns the motor off
  delay(offTime); // waits for offTime milliseconds
}

void motorAcceleration(){
  int delayTime = 50; //time between each speed step
  for(int i = 0; i < 256; i++){
    //goes through each speed from 0 to 255
    analogwrite(motorPin, i); //sets the new speed
    delay(delayTime); // waits for delayTime milliseconds
  }
  for(int i = 255; i >= 0; i--){
    //goes through each speed from 255 to 0
    analogwrite(motorPin, i); //sets the new speed
    delay(delayTime); //waits for delayTime milliseconds
  }
}
```

## NOT WORKING? (3 things to try)

### Motor Not Spinning?

If you sourced your own transistor, double check with the data sheet that the pinout is compatible with a P2N2222A (many are reversed).

### Still No Luck?

If you sourced your own motor, double check that it will work with 5 volts and that it does not draw too much power.

### Still Not Working?

Sometimes the Arduino board will disconnect from the computer. Try un-plugging and then re-plugging it into your USB port.

## MAKING IT BETTER

### Controlling speed:

We played with the Arduino's ability to control the brightness of an LED earlier now we will use the same feature to control the speed of our motor. The Arduino does this using something called Pulse Width Modulation (PWM). This relies on the Arduino's ability to operate really, really fast. Rather than directly controlling the voltage coming from the pin the Arduino will switch the pin on and off very quickly. In the computer world this is going from 0 to 5 volts many times a second, but in the human world we see it as a voltage. For example if the Arduino is PWM'ing at 50% we see the light dimmed 50% because our eyes are not quick enough to see it flashing on and off. The same feature works with transistors. Don't believe me? Try it out.

In the loop() section change it to this

```
// motorOnThenOff();
// motorOnThenOffwithSpeed();
// motorAcceleration();
```

Then upload the programme. You can change the speeds by changing the variables onSpeed and offSpeed.

### Accelerating and decelerating:

Why stop at two speeds, why not accelerate and decelerate the motor. To do this simply change the loop() code to read

```
// motorOnThenOff();
// motorOnThenOffwithSpeed();
// motorAcceleration();
```

Then upload the program and watch as your motor slowly accelerates up to full speed then slows down again. If you would like to change the speed of acceleration change the variable delayTime (larger means a longer acceleration time).

## MORE, MORE, MORE:

More details, where to buy more parts, where to ask more questions:

<http://ardx.org/CIRC03>